

the mouth-organs and eyes, showed the same structure, in equal definiteness and perfection, as the larger castes. Allusion was also made to the ravages of these destructive insects; and some of the modes for exterminating them were explained.

XLIX.—*On the Geological Distribution of the Rhabdophora.*
By CHARLES LAPWORTH, F.G.S.

Part I. HISTORICAL.

[Continued from p. 257.]

(d) *Recent Research.*

GEOLOGICAL.—It has been already shown that those geologists whose leanings were mainly palæontological accepted without question the reference of all prolific Graptolite-bearing strata to the general horizon of the Llandeilo formation, and endeavoured to escape from the numerous difficulties in which they consequently found themselves involved by appeals to the recognized rule of the restriction of certain fossil groups to special sediments, by references to the phenomenon of migration, by the adoption of the theory of "Colonies," and the like. But there were, in addition, a few influential geologists who looked upon geology almost wholly from the physical side, and who naturally relied only upon such palæontological testimony as distinctly coincided with the inferences they drew from the stratigraphical evidences. These viewed all attempts to correlate strata of disconnected areas by means of the Rhabdophora with the gravest suspicion, passing over with a careless indifference the clearest indications of a natural succession afforded by those entered upon their fossil lists. When, as occasionally happened, the palæontological testimony afforded by these fossils conflicted with that drawn from the apparent physical evidences, no matter how scanty or ambiguous, they at once set it aside with undisguised contempt.

However mortifying it may be to the graptolithologist to admit the fact, it cannot be denied that this course was at all events quite as reasonable as the habit of the over-credulous majority. The cautious field-geologist, on consulting the works of those who had made these fossils the subjects of special study, learnt at once that, according to the best authorities, many of the most characteristic Llandeilo Graptolites of Britain occurred in America in the very highest beds of the

representative of the Bala group, that the Upper Llandeilo forms of Scotland predominated in the highest Caradoc rocks of Westmoreland, and that in Bohemia they passed up unaltered far into the rocks of the Third Fauna. In the face of such startling discoveries, he could not fail to reach the conclusion that either the enormously extended vertical range of the various Graptolitic species was out of all proportion to that of the species of the Brachiopoda and Crustacea, or else that our knowledge of the fossils in question was so defective that no reliance could be placed upon it. In either case the result was the same: the Graptolites were clearly valueless as exponents of the geological age of their containing beds.

The Moffat Series.—The special point upon which former theories of the geological range of the British Graptolites may be said to have turned was the distinct reference, by Sedgwick and Murchison, of the richly graptolitic Moffat series to a systematic place inferior to that of the Bala Limestone of North Wales. It is the complete disproof of this erroneous view that has had the most important influence in determining the current of recent research in this direction, as it has necessitated a searching review of the supposed consentaneous evidences upon which former theories were founded, with the result of effecting a marked revolution in many of our previous opinions.

To the hasty investigator these remarkable Moffat rocks appear to be merely a few local bands of black graptolitic shales imbedded in a vast thickness of barren greywackès. Their small vertical extent, and their peculiar physical relations, naturally led all their original investigators to consider them as of very insignificant importance. I have shown elsewhere*, however, that these Moffat beds (instead of forming a single deposit of subordinate geological value, and affording a heterogeneous fauna subject to great local variations, as generally believed) actually embrace three successive formations palæontologically distinct, and of an importance approximating to that of the so-called formations of Siluria. Not only has each of these three formations everywhere a collective fauna peculiarly its own, but the majority of the graptolitic species that characterize it have a very restricted range within it. In the same way it has been made clear that, instead of belonging wholly to the Upper Llandeilo, only a fraction of the Moffat series can, with doubt, be assigned to that sub-formation, its two higher formations representing most distinctly the Caradoc and the Lower Llandovery.

* Quart. Journ. Geol. Soc. vol. xxxiv. p. 240, &c.

Girvan Rocks.—The Girvan district, whence Salter procured the few Caradoc Graptolites enumerated upon his lists, has also been partially worked out by myself. The general succession will be given in the sequel. Its strata, instead of being wholly of Caradoc age, have been found to include representatives of the Lower and Upper Caradoc, the Lower and Upper Llandovery, and the Taramon. The asserted intermingling, in this area, of species elsewhere peculiar to distinct formations has also been ascertained to be purely mythical. Its Graptolites, which are those of the Moffat and Gala groups, correspond precisely in their vertical range with the same species in the eastern districts.

The Coniston Mudstones.—The mistaken views of the geological age of the graptoliferous beds of Westmoreland known as the Coniston Mudstones, or Skellgill shales, were long almost equally effective with those already noticed in delaying a true estimate of the vertical range of the British *Rhabdophora*. By Professors Harkness and Nicholson*, as we have seen, they were at first unhesitatingly assigned to the Bala formation. Professor Sedgwick placed them sometimes in the Bala†, sometimes at the base of the true Silurian. Professor Hughes and Mr. Aveline‡, who have most fully investigated their physical relations, parallel them with the Taranon shales of North Wales. By myself they have long been regarded as of Lower Llandovery age—a view first published by Dr. Nicholson§ and myself in 1875, and subsequently adopted by Professor Harkness|| and Dr. H. Hicks¶. Mr. Marr, the latest student of these beds, agrees with the officers of the Survey in referring them to the Upper Mayhill**. Their Llandovery-Mayhill age may thus be now regarded as practically settled.

Arenig and Llandeilo.—The Arenig and Llandeilo rocks of the neighbourhood of St. David's were carefully studied by

* On page 248, by an unaccountable oversight, Professor Harkness and Sir R. Murchison are together credited with the honour of having originally worked out the general distribution of the fossils in the Lower Palæozoic rocks of the north of England. It is almost needless to point out that the latter name should be that of Professor H. A. Nicholson, whose many accurate and beautiful memoirs upon this subject have (especially for the graptolithologist) made the Lake district classic ground.

† 'Palæozoic Rocks and Fossils,' Introduction, p. xxi; and Quart. Journ. Geol. Soc. vol. i. p. 442.

‡ Geol. Surv. England and Wales, Explan. Sheet 98 N.E. p. 3, &c.

§ Report British Association, 1875.

|| Quart. Journ. Geol. Soc. vol. xxxiii. p. 478.

¶ Geological Magazine, 1876, p. 336, &c.

** Quart. Journ. Geol. Soc. vol. xxxiv. p. 879.

Dr. Hicks in 1874*, and separated for the first time into subordinate groups upon the combined physical and palæontological evidences. Their included Graptolites were subsequently made the subject of a supplementary memoir† by Mr. Hopkinson and myself. Here, for the first time, do we find proofs of the Arenig age of the more typical Skiddaw Slate of the north of England; the distinctness of the Llandeilo graptolitic fauna as compared with that of the true Arenig is rendered tolerably clear; and some progress is made in fixing the peculiar species of its subdivisions.

The Graptolite-bearing rocks of Conway, Tremadoc, Shelve, Meadowtown, Ludlow, Builth, &c. have been partially examined either by Mr. Hopkinson or myself; but our knowledge of the range of the Graptolithina in Wales is still miserably defective.

Ireland.—The rich Graptolite fauna of the Lower Palæozoic rocks of County Down has been most carefully worked out by Mr. William Swanston, F.G.S., and illustrated with great care and completeness‡.

Extra-British Rocks.—The new facts brought to light in Thuringia, Brittany, New York, and the Western Territories will be referred to in their proper place, when the distribution of the extra-British species falls to be discussed.

By far the more important of our new data in this respect are owing to the industry of the Scandinavian palæontologists. As early as 1874 Dr. Tornquist§ marked the presence of many British Graptolites of the Coniston type in the rocks of Dalarna, but, relying upon the documents published up to that date, erroneously paralleled their containing beds with the English Caradoc. M. G. Linnarsson has recently made the vertical distribution of the Graptolites in the Swedish rocks the object of a persevering and most successful study. He has already enriched the literature of the subject with several important memoirs||; and the material he has collected goes far to demonstrate the general identity in range of the forms common to Britain and Scandinavia.

No exhaustive summary of these recent discoveries has hitherto appeared; but several palæontologists have given distinct indications of an appreciation of the value of these new data and of the results to which they converge.

* Quart. Journ. Geol. Soc. vol. xxxi. p. 167.

† Quart. Journ. Geol. Soc. vol. xxxi. p. 631.

‡ Proceedings Belfast Nat. Field Club, Appendix, 1876-77.

§ Öfversigt af K. Vetenskaps-Ak. Förhandlingar, Stockholm, 1874, no. 4, p. 26.

|| Geol. Mag. 1876, p. 241; *ibid.* 1878, p. 278, &c &c.

In a most important note appended to M. G. Linnarsson's paper on the "Vertical Range of the chief Graptolitic Types of Sweden"*, Professor H. A. Nicholson shows that at least four of the successive life-groups of *Rhabdophora* occurring in Sweden are now recognizable as characterizing corresponding formations in Britain.

In his paper on the "Graptolitic Schist of Kongslena"†, M. G. Linnarsson makes a successful comparison of the faunas of the *Lobiferus*- and *Retiolites*-beds of Sweden with those of their equivalents in Britain and Bohemia, and points out the vital bearing of these new facts upon the doctrine of "Colonies."

The geological distribution of the more important genera of the *Rhabdophora* in the five main zones of graptolitic life recognized in the most recent memoirs will be found ably summarized by Dr. Zittel in his recently published 'Manual of Palæontology.'

PALÆONTOLOGICAL.—The palæontological difficulties are also slowly disappearing. In my paper on the "Improved Classification of the *Rhabdophora*"‡, the majority of the known genera were for the first time united into families, in the order of what appeared to be their natural relationships. The union of *Dicellograptus*, Hopk., and *Dicranograptus*, Hall, in the single family of the *Dicranograptidæ*, and the differentiation of the well-marked families of the *Leptograptidæ* (*Nemagraptidæ*), *Dichograptidæ*, and *Monograptidæ* freed us from much of the prevalent confusion, and served to indicate the special lines along which we might expect the more important generic distinctions. The provisional arrangement of the diprionidian forms served also to direct special attention to many structural points of paramount value in the discrimination of homomorphous but distinct species.

The detailed study of the *Rhabdophora* of the prolific South-Scottish rocks has led to the detection of many fresh criteria in the separation of allied species, and has enabled us to correct at a glance the previously inevitably erroneous specific identifications made by our predecessors. The discovery of the distinct invariability of many characters formerly regarded as varietal, in corresponding forms obtained from England, Ireland, and the continent of Europe, has given us a clearer insight into the relative value of specific characters, and has added largely to our ideas of the abundance and variety of the graptolitic species. The careful examination of authenticated examples of the species described by early authors has not

* Geol. Mag. 1876, p. 245. † Ibid. 1878, p. 278. ‡ Ibid. 1873, p. 555.

only demonstrated the erroneousess of many previous identifications, but has resulted in freeing many forms hitherto undescribed, and thus greatly restricting the supposed extended geological range of the earlier and less perfectly described species.

(e) *Classification.*

Classification of the Rhabdophora.—Since the publication of the memoir last referred to, many new facts bearing upon the inter-relationships of these fossils have been detected, but none of sufficient moment to justify us in modifying to any material extent the scheme then proposed. It was pointed out at that time that our available evidence was sufficient to lead us to hope that the monoprionidian forms would be found to be grouped according to their natural affinities. This opinion is distinctly supported by our new data. The arrangement of the diprionidian or petaloid genera, on the other hand, was confessedly temporary and provisional. Here subsequent discoveries show most distinctly that the view then advocated of the possible separation of these forms into two main natural groups, by characters founded upon the presence or absence of the sicula and the single or double character of the cœnosarcal canal, is no longer tenable. This is demonstrated by the fact that the sicula has been detected in the Lasiograptidæ; while several typical Diplograptidæ have been found to possess a single cœnosarcal canal, as in *Retiolites* proper.

The following scheme will be adhered to in the present paper:—

Table of the Families and Genera of the Rhabdophora.

- Fam. I. MONOGRAPTIDÆ. Gen.: *Monograptus*, Gein.; *Cyrtograptus*, Carr.; *Rastrites*, Barr.
- Fam. II. LEPTOGRAPTIDÆ. Gen.: *Leptograptus*, Lapw.; *Pleurograptus*, Nich.; *Cœnograptus*, Hall; *Azygograptus*, Nich. & Lapw.; *Amphigraptus*, Lapw.
- Fam. III. DICHOGRAPTIDÆ. Gen.: *Didymograptus*, M'Coy; *Tetragraptus*, Salt.; *Dichograptus*, Salt.; *Loganograptus*, Hall; *Tennograptus*, Nich.; *Schizograptus*, Nich.; *Ctenograptus*, Nich.; *Clenatograptus*, Hopk.; &c. &c.
- Fam. IV. DICRANOGRAPTIDÆ. Gen.: *Dicranograptus*, Hall; *Dicellograptus*, Hopk.
- Fam. V. DIPLOGRAPTIDÆ. Gen.: *Diplograptus*, M'Coy; *Climacograptus*, Hall; *Cephalograptus*, Hopk.
- Fam. VI. LASIOGRAPTIDÆ. Gen.: *Lasiograptus*, Lapw.; *Glossograptus*, Emmons; *Retiograptus*, Hall; &c.
- Fam. VII. RETIOLIIDÆ. Gen.: *Retiolites*, Barr.; *Clathrograptus*, Lapw.; *Trigonograptus*, Hall; &c.
- Fam. VIII. PHYLLOGRAPTIDÆ. Gen.: *Phyllograptus*, Hall.

